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Energy Saving in a Process Plant using a Steam Accumulator

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Abstract. This work was done in a process plant, where the steam demand was mostly steady but sometimes it peaks-up to the double of the average demand for a short period of time. The plant, in addition to a 5000kg/hr boiler, was continuously operating a huge capacity boiler to encounter this brief situation. This was resulting in unnecessary energy loss. As a solution, a steam accumulator was added on and only a lower capacity boiler was run. The short time peak demand of the plant was satisfied by supplying extra steam from the accumulator for a short period of time. By doing so a saving of about RM 300,000/year was achieved.

1. Introduction

Often it's noticed that, in industries, boilers are oversized or extra high capacity boilers are installed just to overcome a maximum demand that may occur in the plant once in a while. This maximum demand period usually extends over a very short period but needs to be taken care of. In an energy manager's point of view, the above mentioned are undesirable and should be curtailed without affecting the production or operation of the plant. The use of a steam accumulator has emerged as one of the solutions, which is economical and sustainable.

Steam Accumulator is a shell type pressure vessel which stores steam, usually more than required, and supply it where is a need under varying steam load conditions. Boilers are commonly designed for a stipulated capacity at which they could supply steam uninterruptedly which is also its maximum continuous rating. Steam accumulators act as buffer storages between steam generators and demand, whenever there is a difference in steam production and consumption rates [1]. The use of the steam accumulator saves energy, reduces pressure fluctuations, and prolongs the life of tube bundles and pressure vessels in boilers. Installation of a steam accumulator in the local area of high steam consumption is recommended as a remedy by TEEI Handbook, for pressure drop problem and fluctuation [2].

The very first record of a steam accumulator comes from Goldstern and was for balancing the waste-steam from winding machines [3]. Ruths[4] applied it to higher pressure systems with automatic regulation, the application of which until then was limited to a pressure of 2 bar with no automatic operations. A feed water storage system known as constant pressure accumulator is mentioned by Godall [5] in his work as one of the later developments. Lyle [6] in his work describes the developed of high pressure (up to 150 bars) storage systems for Power plants. At present, new systems are being developed



for nuclear power and for solar and other unconventional sources of energy aiming at steam storage volumes of several thousand cubic meters per unit [7].

A steam boiler which is designed for designated steam demand can be run on lower steam demands. But the vice versa, a lower load boiler fulfilling higher steam demands, is not possible. It could be observed that the steam demand for a process is variable and is influenced by various factors. The low load requirements can be easily met by a single dedicated boiler, but higher steam requirements, occurring for a short period of time, cannot be met by the same boiler as it is beyond its design capacity. A steam accumulator is a perfect solution in such a case, as they can store steam generated by a boiler and supply it whenever required. Steam Accumulators are designed to store steam when there is an amount excess of steam when the plant demand is lower than the boiler maximum load. When the process steam demand peaks, the steam from the boiler is topped up with that stored in the accumulator is supplied to fulfil the process requirement.

Installation of a steam accumulator would bring in a huge reduction in boiler size, reducing the installation, operating and the boiler cost itself with increased boiler efficiencies. In a plant, already installed with a boiler of certain design capacity, the process load requirement increases for certain short time period in a day while remains normal with in the maximum capacity of the boiler for rest of the period. This could be due to various reasons.

During the plant planning or commissioning, due consideration should be given on the calculation of the average steam load requirement of their process which will later determine the maximum boiler capacity. For the overload conditions arising, due to the fluctuation of steam load, installation of the steam accumulator can be considered. Determining the capacity of the steam accumulator involves full-time monitoring of the steam flow rates in a process and calculate the excess steam generation along with the overload steam demand. The data collected is typically for a minimum of 2 to 3 days along with any load variations. The maximum capacity of a steam accumulator is estimated based on the data collected.

The process plant studied, currently has two steam boilers to supply all their process steam requirements. Unit-1 is having 5000 kg/hr capacity and unit-2 with 8000 kg/hr, with only one unit running at a time. The plant steam demand normally hovers around 3000 to 3500 kg/hr mostly, however, there were certain times when the demand spikes to a maximum of 6000 kg/hr for a short period of about 30 minutes to an hour, few times day. Due to this particular reason, the plant operators have to run the 8000 kg/hr boiler most of the time in order to meet the surges in demand. Mostly, it will only supply about 3000 to 3500 kg/hr steam which makes the operation less efficient compared to running at higher loads.

The objective of this study is to replace a high capacity 8000 kg/hr boiler, which is hardly used other than during the short high demand period, with an accumulator without compromising the quantity and quality of production. An accumulator acts as buffer storage and does not require energy, resulting in a lot of energy saving, which is calculated and presented in this work. The accumulator technology is in existence since 1900 and was considered obsolete. Careful recalculation of the steam requirement, based on a meticulous energy audit, and a little reengineering will provide an eventual, sustainable and energy economic solution.

2. Methodology

The main idea is to store the surplus energy during low demand period and release it when the peak demands occur. However, we cannot store steam in a vessel due to its low density. It will require a huge storage vessel in order to meet the demand, which of course not practical. Instead, the energy is stored

in water at a steam temperature (saturated water) and it will flash into steam when the huge demand occurs.

For this reason, we will store energy in saturated water at boiler pressure and the output is reduced to the process pressure of 4.5 barg, the steam accumulator will supply steam above the red line, which is beyond what the boiler can supply. On that day, the longest peak demand duration was 30 minutes.

2.1. The System Arrangement

The steam input to the accumulator is control by the steam ‘surplus’ control system. It makes sure that it will not overload the boiler and will only allow steam to enter the vessel during normal load condition. The steam output to the process will be controlled by the steam pressure reducing system. It will make sure the output steam pressure never exceeds the process requirement.

3. Results

The 5000 kg/hr boiler was optimized to achieve better efficiency compared to the bigger boiler so as to manage the short-term peak without running the bigger boiler. According to the demand, the steam accumulator will cater the short-term demand without compromising the other processes.

Calculation for saving

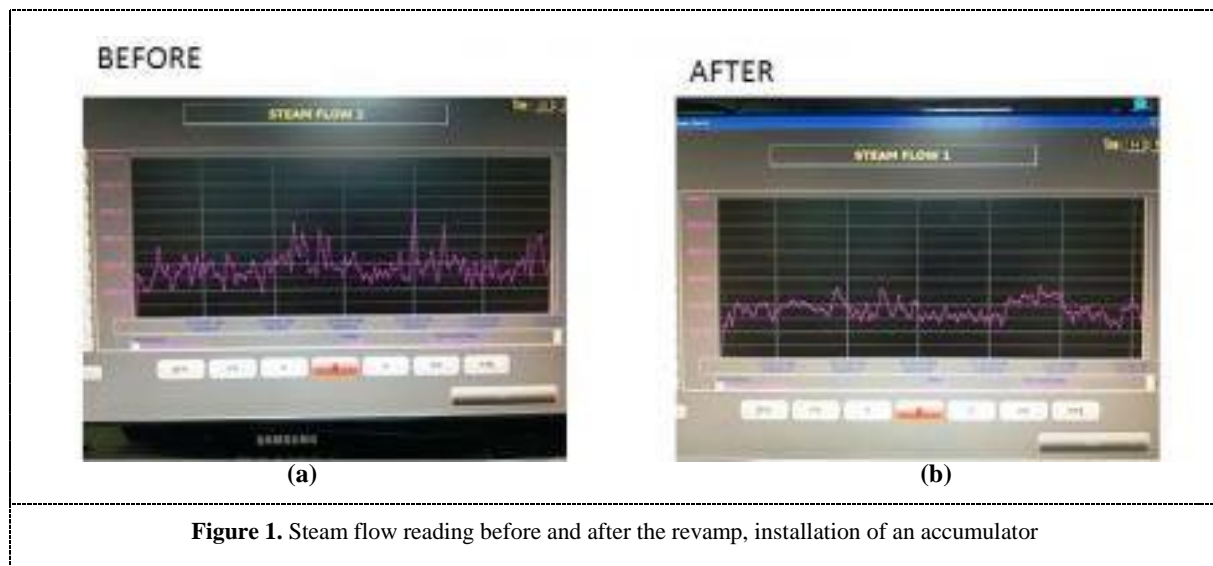
Available Data	
Low load factor – 12 kg of steam per 1 sm ³ Natural Gas	
High load factor – 15 kg of steam per sm ³ Natural Gas	
The total Natural Gas consumption from	
August 2016 until August 2017	
= 2,053,276 sm ³ / 365 days	
= 5703 sm ³ /day	
Average steam generation is 3000 kg/hr	
Operation - 24 hr/ day, 300 days/ year	
Calculation	- total steam generate/ day is 3000 x 24 = 72000 kg/day
	- using low load factor, the Natural Gas consumption is 5703 sm ³ /day
	- using high load factor, the Natural Gas consumption is 4800 sm ³ /day
A saving of 903 sm ³ / day x RM0.96/sm ³	= RM 866.88/ day
Saving for the year (360 days)	= RM 312,076 per year

Referring to Figure 1, we can very well see the pattern of steam flow before was erratic with a lot of peaks corresponding to the extra demand for a short period of time. This, in turn, necessitated the commissioning of a larger, high capacity, boiler just to fulfil these short peak demands.

To save fuel and consistency of the process, a steam accumulator was included in the circuit and the steam flow can be observed in Figure 1(b). The flow is much smoother and maintains a steady average with negligible peaks. Even though this is a case study this can be extended to any plant which has similar circumstances. In each case, well-conducted energy audit and a carefully done accumulator design will be inevitable.

4. Conclusions

The objective of the project, fuel and cost savings, was achieved. The process and the boiler operations became much smoother and easily controllable. The steam accumulators were known for decades and were considered obsolete. But with a little practical knowledge, keen energy auditing and management skills it could be still used to save energy and make the process sustainable. Hence the work establishes the statement made Yang et al. [8] that the steam accumulator acts as a bridge which connects steam generators and consumers smoothly maintaining a balance between supply and demand sides continuous and stable steam balance, so as to maintain the system running load balance, improve the combustion efficiency and save energy. Thus, it could be concluded that with the installation of accumulator a significant amount of RM 312,076 per year could be saved. The investment on the accumulator around RM 750000 the payback period could be calculated will be below 2.5 years which is quite acceptable.



5. Acknowledgements

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